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May 31, 1992

Dr. Erhard Schimitschek, Scientific Officer
ATTN: Code 808
REF: N00014-91-C-0222
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Re:	Contractor	:	Northeast Semiconductor, Inc.
	Address	:	767 Warren Road, Ithaca, NY 14850
	Req. No.	:	s405811srv02/17 APR
	Contract No.	:	N00014-91-C-0222
	Report Date	:	May 31, 1992
	Report Title	:	5th Monthly Technical Report
	Period Covered	:	05/01/92 through 05/31/92

Dear Dr. Schimitschek:

Northeast Semiconductor, Inc. encloses its Fifth Monthly Technical Report (Line Item #0002) pursuant to the provisions of contract Section B entitled, "Supplies or Services and Prices/Costs" for the period of May 1, 1992 through May 31, 1992.

Innovative Techniques for the Production of Low Cost 2D Laser Diode Arrays

1.0 OBJECTIVE

The primary objective of this program is to develop a low cost, high yielding methodology for processing, packaging and characterization of MBE grown two dimensional high power laser diode arrays. Projected increases in overall yield of AlGaAs diode lasers would reduce manufacturing cost from the current \$10 to \$20 per peak watt to below \$3 per peak watt. Emphasis will be placed on innovative packaging techniques that will utilize recent advances in diamond heat sinking technology.

2.0 PROGRAM METHOD AND SCHEDULE

This program consists of four phases which will demonstrate reduced manufacturing cost and improved device performance of NSI's MBE laser diode arrays. The four phases listed below will result in milestones in processing, packaging, and testing along with delivery of the specified number of 5-bar laser arrays.

(i) Concept phase: Conceptual design and organization of this phase II program. NSI will utilize the current side cooled strained relief package to manufacture 5-bar laser diode arrays for base line evaluation. (Deliverables: 3 5-bar arrays.)

(ii) Backplane phase: Development of a copper backplane cooling technology that incorporates CVD diamond submounts. This phase will also include the completion of room temperature photoluminescence development. (Deliverables: 5 5-bar arrays.)

(iii) Diamond Backplane phase: Develop a CVD diamond backplane cooling scheme that will utilize smaller CVD submounts. The reduction in submount size is to decrease the thermal resistance from the laser bar to the backplane. (Deliverables: 5 5-bar arrays.)

(iv) Liquid Cooled Submount phase: An innovative liquid cooled package will be developed. The CVD diamond submounts will be hermetically sealed, electrically isolated and liquid cooled. (Deliverables: 5 5-bar arrays.)

The following global issues not mentioned above will be investigated continuously throughout all four phases of this program:

(1) design and development of a mask set to increase processing and packaging yields,

(2) development and updating of MBE growth software,

(3) design and development of an in-house facet coating station,

(4) evaluation of different facet coating materials,

(5) development of automated tests,

(6) life test and burn-in development.

The master schedule for this program is shown in Table 1. Each phase will require wafer growth, processing, assembly and test. The schedule shows the estimated number of sample fabrications and tests, as well as the time of hardware deliverables and reports.

3.0 PROGRESS THIS PERIOD

3.1 Wafer Growths

NSI has successfully completed negotiations with a Fortune 100 company in East Fishkill, New York for lease of a 3" production MBE machine. Software revisions and minor instrumentation upgrades have delayed growth of laser material this past month. Four 3" calibration wafers have been grown to qualify the machine. The first two wafers were thick layer growths examined by a SEM for calibration of Ga, Al, and In growth rates. The last two wafers were for Be and Si dopant calibration. Growth temperature calibrations were done utilizing a pyrometer to correlate the thermocouple reading to the actual substrate temperature. Additional machine calibration and qualification will take place in the following weeks. Growth of laser material should commence by the end of June upon completion of machine characterization.

3.2 Processing

As stated in the last quarterly report, life time performance difficulties were encountered on the three 5-bar laser diode arrays fabricated for the first phase of this program. These deliverables were all fabricated from the same laser wafer, with 80μm stripes, which has proven reliable at slightly lower operating conditions. However, this material exhibited facet breakdown and developed current leakage paths during burn-in testing to 1 X 10^6 pulses at 60 amps/2% duty cycle. Two possible failure mechanisms were identified; (1) catastrophic facet power density damage and/or (2) side-wall passivation break through. Experiments with narrow stripe (25μm) unfacet coated laser arrays eliminated the possibility of failure due to effects of increased input current and optical output densities. Test results indicate that NSI's unfacet coated laser material can withstand high input current densities up to 3 times normal operating conditions. Therefore, it is believed that the facet failures are related to coating breakdown at higher optical power densities, and not to the laser material. Additional investigation into absorbing impurities and porousity of the coatings need to be done. It has also been shown that reducing the front facet reflectivity will increase the catastrophic optical power damage level.[1] Experimentation on decreasing the front facet reflectance is currently being implemented.

The second possible failure mechanism pertains to current leakage through the side wall polyimide passivation. A portion of wafer M21004 (utilized for the first set of deliverables) has been processed with individual diode metalization to avoid contact with the side walls. The resulting laser bars have been facet coated

[1] M. Ettenberg, H. S. Sommers, H. Kressel, and H. D. Lockwood, Appl. Phys. Lett., 18:571(1971)

and are currently being packaged. Test results will be included in the next monthly report.

3.3 Testing

Efforts this past month focused on life test software development. An initial test selection menu feature is completed and installed to decrease laser array test time. This code will be continually updated throughout this program as the need to simplify and increase testing capability develops. Reliability programming on the current life test source code was also done this past month. An input conversion error from the life test optical power meter has been identified. Software modifications are currently being developed to recognize the potential error and provide corresponding routines to correctly interpret the corrupted data.

3.4 Assembly and Packaging

The submount packaging and array assembly process has remained fixed since last reported. Efforts in packaging has been aimed at increasing yield while significantly reducing the labor and cost involved. Increased participation of outside vendors, along with higher volume bar bonding techniques will be established in the following months.

The following shipment of CVD diamond heat sinks have arrived for evaluation:

11mm x 2mm x 250µm	1000Å Pt/30,000Å Au/2000Å Pt/2000Å Au
11mm x .57mm x 250µm	1000Å Pt/30,000Å Au/2000Å Pt/2000Å Au

The Au/Sn coated pieces have not arrived. The photolithographic metalization originally requested for the larger 2 mm pieces was eliminated to facilitate vendor turn around time. Experimentation with the larger CVD pads have begun at CW powers in an attempt to evaluate the thermal and electrical characteristics relative to previous data from Cu heat sinks. Initial InPb solder deposition and bonding steps are identical to the current Cu submount methods.

Recent attempts in fabricating the third 5-bar deliverable from alternative material continues to be plagued with facet break downs and side-wall leakage discussed in the processing section. Further attempts will be made from individual metalized processed material and recent facet coating runs.

4.0 PLANS FOR JUNE

Laser wafers will be grown during the next month for this program assuming no unexpected machine delays arise. Experimentation will continue on solving device life time issues pertaining to processing and facet coatings. Packaging and testing of material processed with individual diode metalization and recent facet coating will take place. Results of these items should produce the third 5-bar laser array completing the first set of deliverables.

Very truly yours,

Michael J. Cook (Jm)

Michael J. Cook,
Principal Investigator
Northeast Semiconductor, Inc.

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Encl: 1 Copy of 5th Monthly Technical Report

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DEPARTMENT : LASER PRODUCT LINE
PROJECT(S) : SBIR PHASE II
N00014-91-C-0222

KEY
○ : Start Task
◇ : Milestone
△ : Completion Date 1
▽ : Completion Date 2

DATE : NOVEMBER 20, 1991
PREPARED BY : GEOFFREY T. BURNHAM
APPROVED BY :

PAGE 1 of 2

MILESTONES	1991					1992												1993							
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
HIGH YIELD EPITAXIAL GROWTH																									
SYSTEM QUALIFICATION	○				△																				
WAFER STARTS					4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
REVIEW INCOMING INSPECTION	○					△																			
UPDATE GROWTH SOFTWARE	○																							△	
WAFER PROCESSING																									
PROCESSING STARTS					2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
DEVELOP ROOM TEMP PL TEST		○				△							▽												
DEVELOP FACET COATING		○																△							
PACKAGING																									
1-BAR SUBMOUNTS				15	30	30	10	10	10	10	30	30	10	10	10	10	30	30	10	10	10	10	30	30	
5-BAR ARRAYS																									
CURRENT								8																	
Cu BACKPLANE													10												
CVD DIAMOND																			10						
EGW COOLED																									10
TESTING																									
DEVELOP AUTOMATED TESTS	○																							△	
LIFE TESTS/BURN-IN	○																							▽	

TABLE 1. MASTER SCHEDULE FOR SBIR PHASE I
CONTRACT NO. N00014-91-C-0222

DEPARTMENT : LASER PRODUCT LINE
PROJECT(S) : ONR PHASE II
N00014-91-C-0222

KEY
○ : Start Task
◇ : Milestone
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▽ : Completion Date 2

DATE : NOVEMBER 20, 1991
PREPARED BY : GEOFFREY T. BURNHAM
APPROVED BY :

PAGE 2 of 2 MILESTONES (CONTINUED)	1991 A	S	O	N	D	1992 J	F	M	A	M	J	J	A	S	O	N	D	1993 J	F	M	A	M	J	J	A
TESTING (CONTINUED)																									
5-BAR ARRAYS								○																	△
DELIVERABLES																									
REPORTS																									
MONTHLY				△	△		△	△		△	△		△	△		△	△		△	△		△	△		
QUARTERLY						△			△			△			△			△			△			△	
FINAL																									△
5-BAR ARRAYS																									
CURRENT								3																	
Cu BACKPLANE													5												
CVD DIAMOND																			5						
BGW COOLED																									5